

AMENDMENTS TO THE CLAIMS

1 1. (Currently Amended) A digital signal processing system comprising:
2 a delta-sigma modulator having an internal filter coupled to a quantizer, wherein
3 (i) the delta sigma modulator implements a low-pass signal transfer
4 function, (ii) an input sample rate of input samples ~~to~~ received by the delta
5 sigma modulator is an integer multiple greater than one of an output
6 sample rate of the delta sigma modulator, ~~and~~ (iii) the internal filter and
7 the quantizer of the delta sigma modulator operate at the output sample
8 rate f_s , and (iv) the internal filter comprises:
9 a first integrator to process the input samples and generate a first integrator
10 output signal; and
11 a second integrator, coupled to the first integrator, to process first and
12 second input samples and the first integrator output signal during a
13 single cycle of the delta sigma modulator, wherein the first and
14 second input samples represent two successive-in-time samples of
15 an input signal to the delta sigma modulator, the first and second
16 input samples are modified by different gains prior to processing
17 by the second integrator, and the cycle of the delta sigma
18 modulator equals $1/f_s$.

1 2. (Currently Amended) The digital signal processing system of claim 1
2 wherein ~~the output sample rate of the internal filter has a frequency of f_s , and~~ the input
3 sample rate has a frequency equal to N times f_s , wherein N is an integer greater than one.

1 3. (Original) The digital signal processing system of claim 2 wherein N
2 equals 2.

1 4. (Currently Amended) The digital signal processing system of claim 1
2 further comprising:
3 an analog-to-digital converter to convert an analog signal into digital data and
4 provide the digital data to the delta-sigma modulator, wherein the output
5 sample rate of the delta-sigma modulator has a frequency of f_s , and ~~the~~

6 ~~input~~ the input sample rate has a frequency equal to N times f_s , wherein N
7 is an integer greater than one.

1 5. (Original) The digital signal processing system of claim 1 wherein the
2 input data includes an audio signal.

1 6. (Currently Amended) The digital signal processing system of claim 1
2 wherein the delta sigma modulator comprises:
3 a quantizer;
4 a first gain stage, coupled to the first integrator, to modify a first input data
5 sample by a first gain and generate a first gain modified input data sample;
6 a second gain stage, coupled to the first integrator, to modify a second input data
7 sample by a second gain and generate a second gain modified input data
8 sample;
9 a third gain stage, coupled to the second integrator, to modify the first input data
10 sample by a third gain and generate a third gain modified input data
11 sample;
12 a fourth gain stage, coupled to the second integrator, to modify the second input
13 data sample by a fourth gain and generate a fourth gain modified input
14 data sample;
15 ~~an internal filter coupled to the quantizer, wherein the internal filter~~ the first
16 ~~integrator~~ comprises:
17 ~~a first integration stage components to integrate, during the single cycle of~~
18 ~~the delta sigma modulator, a sum of a first sample of input data the~~
19 ~~first gain modified and second gain modified input data samples,~~
20 ~~output data from the a delay stage in an internal feedback path~~
21 ~~from an output of the first integrator, and first negative feedback~~
22 ~~data from the quantizer, wherein the first sample of the input data~~
23 ~~to the first integration stage includes a pair of data samples~~
24 ~~respectively modified by a first gain and a second gain; and~~
25 the second integrator comprises:

26 ~~a second integration stage components~~ to integrate, during the single cycle
27 of the delta sigma modulator, the first sample of the input data
28 third gain modified and the fourth gain modified input data
29 samples, output data from the a delay stage in an internal feedback
30 path from an output of the second integrator, and second negative
31 feedback data from the quantizer, wherein the first sample of the
32 input data to the second integration stage includes the pair of data
33 samples respectively modified by a third gain and a fourth gain;
34 wherein the first and second gains are an independent linear combination with
35 respect to the third and fourth gains.

1 7. (Currently Amended) A method of modulating input data comprises:
2 receiving the input data with a delta-sigma modulator, wherein an input sample
3 rate of the input data to the delta sigma modulator is N times f , wherein N
4 is an integer greater than one and f is a frequency; and
5 processing the received input data using an internal filter and a quantizer of the
6 delta sigma modulator, wherein the internal filter and the quantizer operate
7 at the frequency f , wherein processing the received input data comprises:
8 low pass filtering the input data using the internal filter, wherein low pass
9 filtering the input data comprises: ; and
10 during one delta sigma modulator cycle equal to $1/f$, updating a
11 first integrator with at least one sample of the received
12 input data;
13 generating a first integrator output signal;
14 modifying a first input data sample with a first gain to generate a
15 first gain modified input data sample;
16 modifying a second input data sample with a second gain to
17 generate a second modified input data sample, wherein the
18 first gain is different than the second gain and the first and
19 second input data samples are successive-in-time data
20 samples of the received input data; and

21 during one delta sigma modulator cycle equal to $1/f$, updating a
22 second integrator with (i) the first gain modified input data
23 sample, (ii) the second gain modified input data sample,
24 and (iii) the first integrator output signal;
25 quantizing the input data filtered by the internal filter using the quantizer;
26 and
27 providing output data quantized by the quantizer at an output sample rate
28 of frequency f .

1 8. (Previously Presented) The method of claim 7 wherein low pass
2 filtering the input data further comprises:
3 integrating and decimating the input data at the frequency f .

1 9. (Currently Amended) The method of claim 7 further comprising:
2 converting the input data from an analog signal into a digital signal at a frequency
3 of N times f immediately prior to low pass filtering the input data.

1 10. (Previously Presented) The method of claim 9 wherein N equals 2.

1 11. (Currently Amended) A method of modulating input data sampled at M
2 times a frequency f_s (Mf_s) using a delta-sigma modulator operating at frequency f_s ,
3 wherein M is greater than one, the method comprising:
4 receiving the input data having a sampling frequency Mf_s at an input of the delta
5 sigma modulator;
6 converting the input data into low pass filtered data having a sampled frequency
7 of f_s using an internal filter of the delta-sigma modulator operating at the
8 delta sigma modulator operating frequency of f_s to generate output data,
9 wherein converting the input data into low pass filtered data comprises:
10 [[;]]
11 during one delta sigma modulator cycle equal to $1/f_s$, updating a first
12 integrator with at least one sample of the received input data;
13 generating a first integrator output signal;

14 modifying a first input data sample with a first gain to generate a first gain
15 modified input data sample;
16 modifying a second input data sample with a second gain to generate a
17 second gain modified input data sample, wherein the first and
18 second gains are different and the first and second input data
19 samples are successive-in-time data samples of the received input
20 data; and
21 during one delta sigma modulator cycle equal to $1/f_s$, updating a second
22 integrator with (i) the first gain modified input data sample, (ii) the
23 second gain modified input data sample, and (iii) the first
24 integrator output signal;
25 quantizing the output data of the internal filter using a quantizer operating at the
26 delta sigma modulator operating frequency of f_s ; and
27 providing feedback to the internal filter from the quantizer.

1 12. (Currently Amended) The method of claim 11 wherein converting the
2 input data into low pass filtered data using the internal filter of the delta-sigma modulator
3 further comprises:
4 modifying the first input data sample with a third gain to generate a third gain
5 modified input data sample;
6 modifying the second input data sample with a fourth gain to generate a second
7 modified input data sample, wherein the third and fourth gains are
8 different;
9 during the one delta sigma modulator cycle equal to $1/f_s$, updating the first
10 integrator with (i) the third gain modified input data sample, (ii) the fourth
11 gain modified input data sample, and (iv) first quantizer feedback;
12 ~~providing first and second data samples and first quantizer feedback data at the~~
13 ~~same time to a first integration stage of the internal filter, wherein the first~~
14 ~~and second data samples provided to the first integration stage are~~
15 ~~respectively modified by a first gain and a second gain;~~
16 during the one delta sigma modulator cycle equal to $1/f_s$, further updating the
17 second integrator with ~~providing the first and second data samples and~~

18 ~~second quantizer feedback at the same time to a second integration stage~~
19 ~~of the internal filter, wherein the second integration stage receives output~~
20 ~~data from the first integration stage and the first and second data samples~~
21 ~~provided to the second integration stage are respectively modified by a~~
22 ~~third gain and a fourth gain;~~
23 wherein the first and second gains are an independent linear combination with
24 respect to the third and fourth gains.

1 13. (Previously Presented) The method of claim 11 further comprising:
2 converting the input data from an analog signal into a digital signal at the
3 frequency of Mf_s immediately prior to converting the input data into low
4 pass filtered data at a frequency of f_s using the internal filter of the delta-
5 sigma modulator.

1 14. (Previously Presented) The method of claim 11 wherein N is two.

1 15. (Original) The method of claim 11 wherein the input data includes an
2 audio signal.

1 16. (Original) A recording media encoded with data based on the output
2 data generated using the method of claim 11.

1 17. (Currently Amended) A method of using an internal filter of a delta-sigma
2 modulator to decimate and integrate an input signal, the method comprising:
3 modifying a first data sample of the input signal by a first gain and,
4 independently, by a second gain;
5 modifying a second data sample of the input signal by a third gain and,
6 independently, by a fourth gain, wherein the first and second data samples
7 are successive-in-time samples of the input signal;
8 during one delta sigma modulator cycle, providing first and second data samples
9 modified by the respective first and third gains and first quantizer
10 feedback data at the same time to a first integration stage integrator;

11 ~~wherein the first and second data samples provided to the first integration~~
12 ~~stage are respectively modified by a first gain and a second gain;~~
13 during one delta sigma modulator cycle, providing the first and second data
14 samples modified by the respective second and fourth gains, ~~and second~~
15 quantizer feedback, and output data from the first integrator at the same
16 ~~time to a second integration stage integrator,~~ wherein the second
17 ~~integration stage receives output data from the first integration stage and~~
18 ~~the first and second data samples provided to the second integration stage~~
19 ~~are respectively modified by a third gain and a fourth gain;~~
20 integrating output data from the second ~~integration stage~~ integrator using N-
21 subsequent integration stages to generate quantizer input data, wherein N
22 is any non-negative integer;
23 quantizing the quantizer input data; and
24 wherein the first and second gains are an independent linear combination with
25 respect to the third and fourth gains.

1 18. (Previously Presented) The method of claim 17 wherein providing
2 the first and second data samples further comprises providing the first and second data
3 samples directly from an analog-to-digital converter.

1 19. (Original) The method of claim 17 further comprising:
2 using the quantized input data to encode an audio signal on a recording medium.

1 20. (Currently Amended) An apparatus for modulating input data sampled at
2 N times a frequency f_s (Mf_s) using a delta-sigma modulator operating at frequency Nf_s ,
3 wherein M is greater than N, the apparatus comprising:
4 means for receiving the input data having a sampling frequency Mf_s at an input of
5 the delta sigma modulator;
6 means for converting the input data into low pass filtered data having a sampled
7 frequency of f_s using an internal filter of the delta-sigma modulator
8 operating at the delta sigma modulator operating frequency of f_s to

9 generate output data, wherein the means for converting the input data into
10 low pass filtered data comprises:
11 means for updating a first integrator with at least one sample of the
12 received input data during one delta sigma modulator cycle equal
13 to $1/f_s$;
14 means for generating a first integrator output signal;
15 means for modifying a first input data sample with a first gain to generate
16 a first gain modified input data sample;
17 means for modifying a second input data sample with a second gain to
18 generate a second gain modified input data sample, wherein the
19 first and second gains are different and the first and second input
20 data samples are successive-in-time data samples of the received
21 input data; and
22 means for updating a second integrator with (i) the first gain modified
23 input data sample, (ii) the second gain modified input data sample,
24 and (iii) the first integrator output signal during one delta sigma
25 modulator cycle equal to $1/f_s$;
26 means for quantizing the output data of the internal filter using a quantizer
27 operating at the delta sigma modulator operating frequency of f_s ; and
28 means for providing feedback to the internal filter from the quantizer.